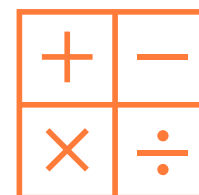


THE NATURE OF NUMBERS



We all have a history when it comes to numbers, mathematics, and science. For most people these experiences are tied to schooling: that maths teacher you had all throughout high school; all the words of encouragement (or discouragement) from your friends, peers, and family; and the grades you would receive for maths and science subjects, year over year.



While a great deal of learning is accomplished in school, it is also easy to become misguided about the true nature of spatial and number-based problem solving during this time. This can lead to misconceptions about the importance of numbers for learning at university, and sometimes it leads to avoidance or anxieties about science and mathematics in our study and in our everyday lives.

In this module, we will be learning to:

- Become familiar with the symptoms of maths anxiety and acknowledge its prevalence in modern societies;
- Define the true nature of mathematics as a science of patterns and puzzles; and
- Rediscover our innate sense of creativity for spatial and number-based problem solving.

HOW WE THINK ABOUT NUMBERS & MATHS IS IMPORTANT

Our perceptions can greatly influence our motivation and confidence to learn more about science, technology, engineering, and mathematics (STEM). For many of us, confronting a mathematical problem can make us feel:

- overwhelmed
- stressed
- frustrated
- anxious

The effect of this maths anxiety is much like stage-fright where speaking to a public audience, or even just the thought of it, can cause a lot of unnecessary nervousness and worry. This can lead to an avoidance of science and maths (just like an avoidance of public speaking), affecting important aspects of our work, career choices, and important everyday tasks and hobbies. Research suggests that around 20%, or 1 in every 5 people, experience this kind of anxiety about mathematics.

WHAT DOES MATHS ANXIETY FEEL LIKE?

- Avoidance of maths learning and number-based problem solving.
- Feeling of nervousness, unease, and anxiety when attempting numeracy problems, especially when other people are around.
- Freezing, forgetting simple things you know about maths, or intense nervousness (elevated heart rate, sweating, nausea, etc.) before and/or during maths tests or examinations.



WHAT CAUSES MATHS ANXIETY?

- A false belief that our ability to do maths is fixed. We often learn this false belief from other people, such as friends, parents, and teachers. Have you ever heard someone say: “I am not a maths person”, “my friend is a maths whiz”, or “I was never good at maths when I was at school”. These comments reflect a belief that maths is something we are either naturally good at, or naturally bad at, and that nothing much can be done about it. This simply isn’t true! With effort, patience, and persistence,

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everyone can learn more about maths and discover its countless uses (and conveniences) for study, in the workplace, and in everyday life.

- Negative learning experiences. There's nothing more discouraging than trying your hardest but getting a poor result. This may happen when receiving low grades in maths class, feeling confusion or even embarrassment at trying to solve a difficult maths problem in front of others (especially if they disagree with your calculation), or having to learn maths that is too complex for you now, especially if its relevance is not obvious. These experiences may further contribute to the false belief of fixed maths ability; however, when these challenges are embraced with effort, patience, and persistence, they can become much less discouraging.
- Threat of social stereotype. It has become commonplace in modern Western culture that it is socially acceptable to have poor or underdeveloped proficiency for numeracy. This is a terrible shame! Learning and knowing more about maths can help us to better enjoy our lives and understand the world we live in. Short of announcing to all your friends and family that "maths is cool", don't let anyone tell you that "it's just maths, it doesn't matter".



HOW CAN MATHS ANXIETY BE OVERCOME?

- Recognise that you can learn more about maths and numbers with time, effort, patience, and persistence, regardless of where you currently are in your learning journey.
- Embrace feelings of frustration and struggle when trying to learn new things. This is not maths anxiety; it is the feeling of your brain working overtime to try and connect new ideas with your existing thoughts and memories. The more frequently you feel this frustration and struggle, the more you will learn! There are very good reasons why people suggest that practicing a little each day is better than cramming.
- Explore your curiosity for maths. Whatever your interests, such as sport, art, design, or tech, it is certain that your depth of understanding and your enjoyment of these interests can be enhanced by better understanding the patterns and spatial relationships that make them so attractive to you. How well do you really know your hobbies?
- Manage feelings of anxiety. Anxiety is a natural feeling that our brains instinctively engage when there is a possible or probable threat to us. It keeps us safe and on the lookout for danger. Next time you feel this way about maths, be mindful of why your brain has kicked into this heightened sense of awareness. Are numbers really a threat to your safety? Or have you been tricked into thinking that maths is more threatening than it really is?



WHAT IS THE TRUE NATURE OF MATHEMATICS?

Anxious feelings can make numbers and math problems seem distant, unfamiliar, and threatening. But not everyone sees it this way. Next time you are walking through a park, hiking through the bush, or browsing the aisles of a supermarket, take a close look at the patterns and the numbers that surround you. They are everywhere!

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Mathematical patterns are all throughout nature:

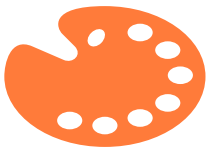
- The splintering patterns found in lightning strikes, blood vessels, and river deltas;
- Spiralling patterns you can see in flowers, seashells, and stormy weather systems; or
- The different hexagonal, cubic, or prism shapes of crystals, honeycomb, and snowflakes.



What do these have in common? How are they similar? How are they different? Gaining a better understanding of these patterns can help us to discover and develop new technologies, new therapies for human diseases, or new economic strategies for prosperity and sustainability. It is surprising how many social, technological, and economic developments have risen from the patterns we have come to understand in nature; the *mathematics* we see in nature.

These are the real questions that scientists and mathematicians ask, and these are the types of questions from which science and mathematics have become integral to our lives.

MATHS IS CREATIVE!



So far, we have learned that despite the prevalence of maths anxiety (maths-fright!) mathematics is nothing to be fearful of. It is closely connected to the patterns we see in nature and in our society, and it is something that everyone is capable of learning more about. We have also briefly seen that science and mathematics are very much focused on asking questions about the patterns we see. When we ask these questions, patterns become puzzles, and the human brain is instinctive when it comes to puzzle-solving.

Think of the sources of entertainment that you find most enjoyable. The most engaging are typically those that elicit our brain's creativity for puzzle-solving:

- video games that challenge us to discover new solutions to a problem or develop new skills that allow us to reach the next level;
- movies or television series that have complex plots, different pieces of evidence to consider, or a conflict of strengths and weaknesses between heroes and adversaries;
- music, paintings, and poetry, where the artist's intentions, desires, and interpretations are debated; or
- hobbies such as gardening, cooking, carpentry, and home projects, in which we have personal goals and design aspirations.

The creativity that we exercise for recreation is no different to mathematical problem solving. Every maths problem is a puzzle that challenges us with different questions, situations, interpretations, outcomes, and implications. The formulas, rules, and algorithms we often see in mathematics class are frequently misunderstood as the heart and soul of maths. Whereas they are merely an expression of the strength of problem-solving capabilities in maths; they are the tools of the trade. It is in fact our interest in puzzles, and the creativity that we instinctively deploy when tackling them, that is the real heart and soul of mathematics.

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TIPS FOR CREATIVE PROBLEM SOLVING

The key to maths and numbers is creative problem solving; a skill that you can intuitively engage with and enjoy exploring. It isn't just about memorising formulas. Consider these three tips when trying to solve your next maths problem:

- Always write or draw your problem solving on paper. Sometimes the question or situation itself seems difficult to understand and often this is half the battle. Expressing the problem, or at least parts of the problem, in visual form will help your brain to see all the different parts and how they might fit together. Your brain's working memory is very limited, so it will almost never work to simply try and solve a problem 'in your head'!
- Think deeply and creatively about all the ideas and possible solutions you can come up with. Getting to an answer is not the most important thing when problem solving, it's the journey that really matters. Plus, there may be more than one answer!
- If you experience feelings of frustration or struggle, that is a good thing! It means that your brain is working overtime to create new neural connections. Just like lifting weights in the gym and feeling your muscles begin to tire, your brain is getting a workout and it will get stronger every time you exercise it in this way. You may also need a good night's sleep between practice sessions to properly rest your brain and to move all that training effort (learning) to long-term memory.

NUMBERS ARE IN OUR NATURE

So, what is the nature of numbers?

1. Our perceptions of numbers and science can dramatically affect our motivation and abilities to tackle mathematical problems. Broadly speaking, we have a choice to approach maths with fear and anxiety, or with curiosity and a growth mindset for learning.
2. Maths is the science of patterns and puzzles. From the spiral shape of a nautilus seashell to the fractal pattern of our blood vessels, maths is undeniably connected to nature and the world we live in.
3. The human brain is a creative and instinctive puzzle-solving machine. Even from a young age our brains have enjoyed exploring the patterns and puzzles around us. This same curiosity fuels our interest in hobbies and entertainment, which are often math problems in disguise.



Clearly, numbers are in our nature!